

10/519563

DT01 Rec'd PCT/PTO 30 DEC 2004

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application No. :

U.S. National Serial No. :

Filed :

PCT International Application No. : PCT/DE2003/002417

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*NT Simpkin*

Date: November 18, 2004

Full name of the translator :

Neil Thomas SIMPKIN

For and on behalf of RWS Group Ltd

Post Office Address :

Europa House, Marsham Way,  
Gerrards Cross, Buckinghamshire,  
England.

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10/519563

WO 2004/017093

PCT/DE2003/002417

DT01 Rec'd PCT/PTC 30 DEC 2004

SENSOR FOR TRANSMITTING AND RECEIVING ELECTROMAGNETIC SIGNALS

The invention relates to a sensor having a housing in  
5 which a transmitting antenna array for transmitting electromagnetic transmission signals in a radiation area, and a receiving antenna array for receiving reception signals which are reflected at at least one object within the radiation area are arranged.

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Such sensors are increasingly used, in particular as radar sensors, for sensing the surroundings of vehicles. In the extreme short range, radar sensors are used to form parking aids. Furthermore, it is known  
15 that radar sensors can also be used to monitor the lane behind a vehicle and also next to a vehicle, in order, for example, to warn the driver of an automobile against risks of collision when overtaking, opening doors etc.

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The sensors must generate transmission signals in a suitable way. It is known to transmit transmission signals in the form of an individual pulse and to determine the time after which a reflected reception  
25 signal has been received. The distance between the object and the sensor is determined from the time difference between the transmission and the reception of the pulse.

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It is also known (DE 100 50 278 A1) to change the frequency of the transmission signals in a skilful way in order to be able to determine a location and a speed from the frequency of the transmission signal at the time when a reflected reception signal is received, and  
35 from the frequency of the reception signal. The transmission of the signals whose frequency has been changed can be carried out virtually continuously.

- 2 -

In order to monitor the various surrounding areas of a vehicle, it is thus necessary to use in each case different sensors which are provided with the corresponding controllers for shaping the transmission signals. This entails considerable financial outlay.

The present invention is therefore based on the object of specifying a sensor of the type mentioned at the beginning which permits the surroundings to be sensed in a more economical way, in particular for vehicles.

In order to achieve this object, a sensor of the type mentioned at the beginning is characterized according to the invention in that the transmitting antenna array is designed to transmit transmission signals in a main radiation area and in a secondary radiation area which is at an angle thereto, and in that the receiving antenna array is configured to receive reception signals which are reflected in both radiation areas.

The sensor according to the invention thus permits two areas which are at an angle to one another to be monitored with a single sensor, preferably with a single transmitting antenna. The transmitting antenna array is designed in such a way that, in addition to its lobe-shaped main radiation area, it has a distinct, lobe-shaped secondary radiation area.

It is basically known that, in addition to the radiation area or reception area which is used, antennas also have low levels of sensitivity in secondary lobes. The antennas are generally tuned in such a way that the secondary lobes as far as possible are suppressed because in this way generally undesired signal transmissions or signal receptions are brought about.

In contrast with the above, according to the invention

- 3 -

the transmitting antenna array is designed in such a way that the transmitting antenna array has a secondary lobe which is as distinct as possible and which is designed to be used for transmitting transmission signals.

A distinct secondary lobe is formed on a single transmitting antenna in particular by virtue of the fact that the transmitting antenna is actuated in such a way that the main radiation area is at an acute angle to a geometric orientation of the transmitting antenna. This is referred to as a squinting antenna. In a squinting antenna, a distinct secondary lobe can be formed in the opposite direction from the squinting direction.

The acute angle (squint angle) is preferably between  $10^\circ$  and  $30^\circ$ , and preferably equal to  $20^\circ$ .

In one preferred embodiment of the invention, the transmission range in the main radiation area is more than twice as large, preferably more than four times as large, as in the secondary radiation area. For a use in a motor vehicle it is advantageous to make the range in the main radiation area between 30 and 50 m, and in the secondary radiation area between 2 and 10 m. The angle between the main radiation area and the secondary radiation area is preferably more than  $45^\circ$ .

In one expedient embodiment of the invention, the receiving antenna array can have two receiving antennas, one of which is aligned with the main radiation area, and the other of which is aligned with the secondary radiation area.

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However, it is also possible to form the receiving antenna array with a single receiving antenna which is configured for receiving reception signals which are

- 4 -

reflected from both radiation areas.

It is also possible to form the receiving antenna array with two preferably identical receiving antennas which  
5 are both respectively configured to receive reception signals which are reflected from both radiation areas, as a result of which additional angle information can be obtained.

10 The transmitting antenna and the receiving antenna or antennas are preferably embodied as planar antennas so that the sensors can be of space-saving design.

15 The invention will be explained in more detail below by means of an exemplary embodiment which is illustrated in the drawing, in which:

figure 1 shows a transmitting antenna with a main radiation area and a secondary radiation area,

20 figure 2 is a schematic illustration of a vehicle with a radar sensor with a transmitting antenna having the properties according to figure 1, and

25 figure 3 is an illustration of a transmitting antenna and two receiving antennas as planar antennas.

Figure 1 illustrates an antenna array whose reception area of a receiving antenna is indicated by an ellipse  
30 2 which is represented by dashed lines.

A planar transmitting antenna 1 irradiates from its irradiation surface in a lobe-shaped main radiation area 3 and a secondary radiation area 4, which is also  
35 lobe-shaped.

The distinct secondary radiation area 4 is formed in that the transmitting antenna 1 is actuated in such a

- 5 -

way that the main radiation area 3 is not symmetrical with respect to the perpendicular to the plane (irradiation surface) of the transmitting antenna 1 which is embodied as a planar antenna, but instead 5 forms an angle of approximately 20° with the perpendicular. Owing to the squinting of the main radiation area 3, the distinct secondary radiation area 4, whose central axis includes an angle of > 45° with the central axis of the main radiation area 3, and can 10 also be 90° and even slightly above, is produced.

Figure 2 clarifies that the transmitting antenna 1 is expediently embodied in a motor vehicle 5 obliquely, at the squint angle, so that the main radiation area 3 15 extends approximately parallel to the longitudinal axis of the motor vehicle 5. The secondary radiation area 4 then extends into a region to the side of the motor vehicle 5 if the transmitting antenna 1 is mounted on a rear corner of the motor vehicle 5, viewed in the 20 direction F of travel.

The position of a driver of the motor vehicle 5 is indicated by a continuous circle 6, and for example the field of vision of the driver who is looking in the 25 direction F of travel is indicated by a dotted line 7. It thus becomes clear that the secondary radiation area fills virtually the entire dead angle of the driver at the position 6.

30 It is thus possible to use a single transmitting antenna array to monitor the area behind the motor vehicle 5 in order to detect approaching vehicles on one or more lanes, and to monitor the area next to the motor vehicle 6 in order to sense the dead angle of the 35 driver.

The range preferably extends in the main radiation area 3 to 30 to 50 m, while the range in the secondary

- 6 -

radiation area 4 can appropriately be between 2 and 10 m. The range in the secondary radiation area 4 typically extends to approximately 5 m.

5 Figure 3 illustrates an example of a planar transmitting antenna 1 (TX) which is composed of 24 transmitting pads 8 which are actuated in such a way that a desired transmission characteristic is set. In the case of figure 1, the transmission characteristic  
10 for a squinting antenna is set.

The receiving antenna array RX is composed of two receiving antennas 9, 10 which are formed from two linear arrays of receiving pads 11. Their actuation  
15 determines the receiving characteristic of the receiving antennas 9, 10. The receiving antennas 9, 10 are each configured for the reception of reception signals which are reflected in the main radiation area 3, and for the reception of reception signals which are  
20 reflected in the secondary radiation area 4. It is possible to divide signals in the receiving antenna array and it is possible to detect whether an approaching object is located behind the motor vehicle 5 in the main radiation area 3, or next to the motor  
25 vehicle 5 in the secondary radiation area 4, if an angle is determined from the phase difference of the received signals using the monopulse method.

Each of the receiving antennas 9, 10 can therefore be  
30 configured to receive reception signals from both radiation areas 3, 4.